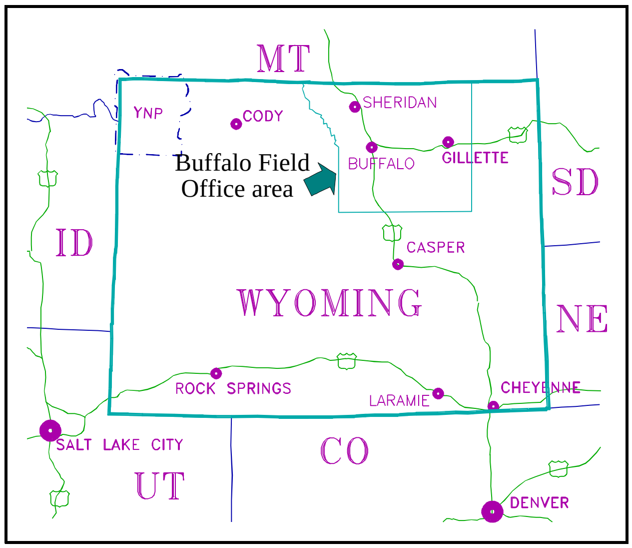
APPENDIX C

REASONABLY FORESEEABLE DEVELOPMENT SCENARIO FOR OIL AND GAS DEVELOPMENT IN THE BUFFALO FIELD OFFICE AREA, WYOMING

SUMMARY

Estimating how much oil and gas activity will occur on federal acreage in the Buffalo Field Office Area (BFOA) during the next ten years is at best difficult. It is expected that, with a few exceptions, all public domain and acquired minerals will be available for leasing as indicated by the current land use plan. Review of oil and gas price, occurrence potential, play analysis, and leasing, seismic, drilling, and production activities was needed to understand the oil and gas resource potential. This information was used to project activity through 2010. Where appropriate, the coalbed methane (CBM) resource is discussed separately from conventional oil and gas.

The BFOA is in northeast Wyoming (Figure 1) and most of it lies in the Powder River Basin. Fifteen oil and gas plays have been identified and are summarized by the U.S. Geological Survey (Dolton 1990). An oil and/or gas play is an area, geologic formation, or geologic trend which has good potential for oil and/or gas development or is generating a large amount of interest in leasing and drilling.



<u>Figure 1</u> Index map showing location of the Buffalo Field Office area.

The CBM play covers the central part of the BFOA and is currently one of the most active gas plays in the country. Ninety eight percent of the CBM resources are in Campbell, Johnson, and Sheridan counties, Wyoming. Converse and Natrona counties contain the remaining two percent. Montana contains about two percent of the total estimated CBM resources in the Powder River Basin, excluding native lands.

Federal oil and gas leasing through 2010 will average between 100,000 and 500,000 acres per year. Average bids are expected to be between $10 to $50 per acre. From February 1990 to August 1999, the BLM received $83 million in oil and gas lease bonuses for the BFOA. About $51 million of that total is estimated to be directly attributed to CBM interest.

Seismic activity on BLM administered surface will average 15 surveys per year through 2010. Most will be three dimensional surveys rather than the two dimensional surveys common in the past. Most seismic activity will continue to occur in Campbell County.

Through 2010, non CBM federal wells are expected to be drilled at an average of 30 to 150 per year, but, could be as high as 200 per year. New non CBM field discoveries will average five to ten per year, with average field size being two to five wells.

Future CBM drilling was estimated, using 28 trillion cubic feet of gas as the recoverable reserve. This is the high estimate, but was used so that the largest potential impact could be assessed. Three reasonably foreseeable development scenarios for CBM, were calculated based on different average well recoveries. The moderate scenario projects 81,000 total CBM wells in Wyoming, with 50,000 wells drilled by 2010. The high scenario projects 139,000 total wells, with 80,000 being drilled by 2010.

BFOA oil production in 1998 was 17 million barrels. Although oil production may show minor year-to-year increases, overall it is anticipated to decline about five percent per year over the period reviewed. This projection could change if a major oil play develops or prices increase substantially and stabilize. Oil production from federal leases will continue to be about 50% of total oil production.

Non CBM gas production declined from 3.4 billion cubic feet of gas (BCFG)/month in January 1986 to 1.3 BCFG/month in January 1999. Although there may be year-to-year increases, the decline in non CBM gas production is expected to continue through 2010.

CBM production increased from 0.28 BCFG/month in January 1995 to 4.57 BCFG/month in June 1999, an average annual increase of 62 percent. Annual gas production rates are expected to continue to increase through 2005. Production rates will then level off for a few years before starting to decline. During June 1999 14 million barrels of water (1,800 acre feet) were produced.

Currently there are about 1,282 productive federal non-CBM oil and gas wells in the BFOA. Although the number of producing oil wells may increase slightly year-to-year it will almost certainly decline over the next ten years. During the next ten years the number of federal non CBM wells abandoned will exceed the number of federal non CBM wells drilled.

INTRODUCTION

APPENDIX C

The following scenario presents an estimate of future activity within the BFOA, under the current land use plan, unless otherwise noted.
It was assumed that all public domain and acquired minerals would be available for leasing and development without excessive restrictions, except for:

$ wilderness and wilderness study areas (only the Fortification Creek Wilderness Study Area, 12,419 acres mostly in T. 52 N., R. 72 W., has high oil and gas occurrence potential);

$ selected areas within federally approved coal mine plans; and

$ Wyoming Game and Fish big game winter ranges adjacent to the Bighorn National Forest.

Impacts caused by oil and gas development, and impacts to oil and gas development cannot be assessed without estimating future oil and gas activity. Estimates of future activity need to take into account:

$ crude oil and natural gas prices and anticipated price changes;

$ oil and gas occurrence potential;

$ oil and gas play analysis (including looking at the potential development of new plays such as horizontal drilling in the Niobrara Formation or CBM development) or renewed interest in old plays;

$ leasing;

$ seismic surveys, including advances in three-dimensional analysis;

$ drilling; and

$ production, including advances in, and application of technology, such as secondary and enhanced oil recovery.

The above factors cannot be predicted with certainty, but some generalizations are possible. The estimates presented here are based on past activity and trends and anticipated future price increases. Those estimates may be lower than what actually happens if price and play developments are more positive than anticipated. Likewise, if exploration in existing plays is disappointing, new plays are not developed, and/or commodity prices are less than anticipated, these estimates may be optimistic.

OIL AND GAS PRICES

The annual change in oil price for the lower 48 states was estimated to range between -1.3 and +1.5 percent for the 1999-2020 period (Energy Information Administration 1998), with a best guess increase of 0.4 percent per year (Figure 2). The actual increase in oil price the past few years has been much higher than predicted. Wyoming sweet crude prices, as reported by Conoco, Inc., were $8.13 in December of 1998 and increased to $24.89 in December of 2000. Average U.S. petroleum consumption is estimated to increase 18 to 46 percent during 1999-2020 (Energy Information Agency 1998).

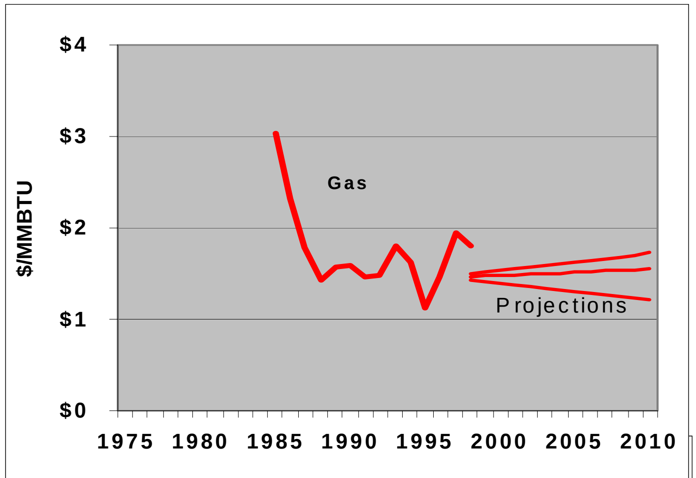


Figure 3 Historic gas prices (Wyoming State Geological Survey 1996) and projections (Energy Information Administration 1998).

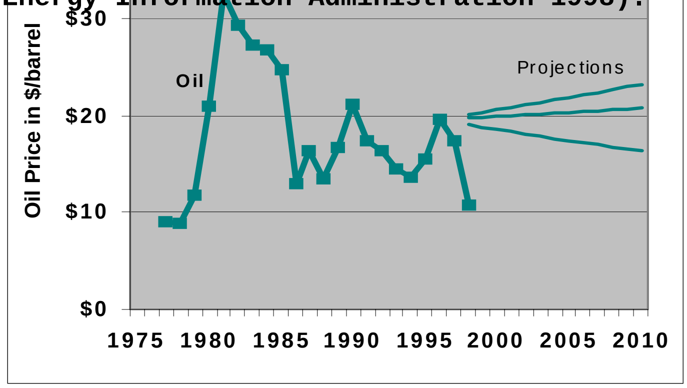


Figure 2 Historic oil prices (Wyoming State Geological Survey 1996) and projections (Energy Information Administration 1998).

The average annual change in gas price was projected to be between -0.7 and +1.2 percent during 1999-2020, with a best guess increase of 0.5 percent (Energy Information Administration 1998). Figure 3 shows this projection. The actual increase in gas price the past few years has been much higher than predicted. Opal sweet gas spot prices, as reported by the Oil and Gas Journal, were $2.00 in December of 1998 and increased to $6.00 in December of 2000.

OIL AND GAS OCCURRENCE POTENTIAL

Projection of future oil and gas activity must first consider where those resources might occur. To do this an occurrence potential map was constructed (Map 1). The oil and gas occurrence potential was classified as High, Moderate, Low, or None. Explanation of these classifications is given on the map. Note that most of the BFOA has high occurrence potential. The classification is based on geology, data from oil and gas test wells, and the play areas described by Dolton, et al (1990). The Geologic Map of Wyoming (Love and Christiansen 1985) and the Structure Contour Map of the Powder River Basin and Casper Arch, Wyoming and Montana (Petroleum

Information 1987) were also used. Map 1 does not indicate whether these resources can be developed economically.

OIL AND GAS PLAYS

Non CBM Plays

Fifteen oil and gas plays in the BFOA were identified and described by the U.S. Geological Survey (Dolton, et al 1990). An oil and gas play is an area where a geologic formation can contain oil and/or gas deposits. These plays are summarized in Table 1. Nearly all the hydrocarbons produced from fields within the BFOA are from these plays. The amount of undiscovered oil and gas remaining in the BFOA cannot be estimated from the information in Table 1. This is because geologic heterogeneity, uneven distribution of resources, and reservoir size variations keep hydrocarbons from being evenly distributed across a play area. Two plays not reported by Dolton, et al (1990) are the CBM gas play and the Niobrara Formation fractured shale play.

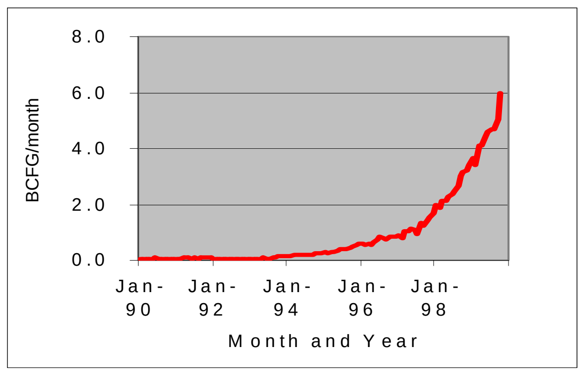


Figure 4 CBM production for BFOA.

(CBM) Play

During deposition and compaction of the organic material which ultimately becomes coal, large quantities of methane gas are generated. Methane gas produced from coal has a lower energy (BTU) content than other natural gas produced in the BFOA. Methane molecules are trapped by adsorption in the coal micro pores, and porosity.

The BFOA contains some of the largest coal deposits in the country. The most extensive coal beds are in the Paleocene age Tongue River member of the Fort Union Formation.

The approximate area of potential CBM development can be defined based on depth to coal and coal thickness (Map 2). The play was one of the most active gas plays in the country for 1998-2000. Initially, wells were less than 500 feet deep and were concentrated just west of coal mines on the plays east side. Over time, well depths have increased and growth of the play has extended to the west. Many new wells are more than 1,000 feet deep. To develop the deepest coals in the Tongue River member, wells may need to be drilled as deep as 3,000 feet.

In October 1999 there were over 1,230 producing and 900 shut-in wells in the play. Figure 4 shows CBM production from the BFOA.

Production for October 1999 was 5.8 BCFG. The BFOA experienced a production increase that averaged 62% per year for the period October 1994-October 1999. Lack of pipeline capacity limited production until late 1999 when two new lines were completed into the Powder River Basin. Based on Wyoming Oil and Gas Conservation Commission data, cumulative CBM production through October 1999 was 110 BCFG.

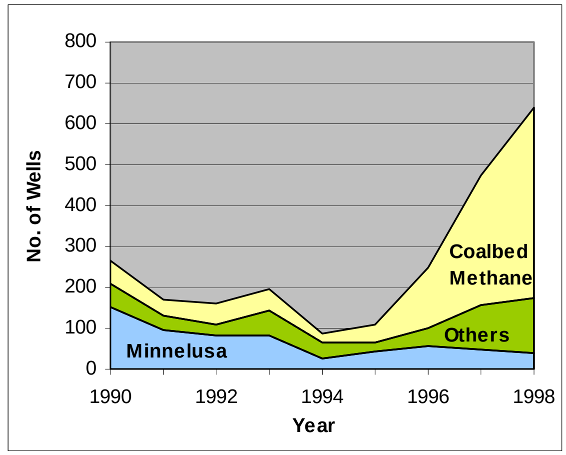


Figure 5 Wells drilled in the BFOA during 1990-1998. Data are from PI/Dwights.

CBM resource estimates (Potential Gas Committee 1998) for the Powder River Basin range from 4,664 to 15,859 BCFG with a best guess of 9,329 BCFG. The U.S. Geological Survey also estimated the CBM resources in the Powder River Basin, but their estimate is several years old and was made before the play began rapid and extensive expansion. Their estimates appear to be too low and were not used in this analysis.

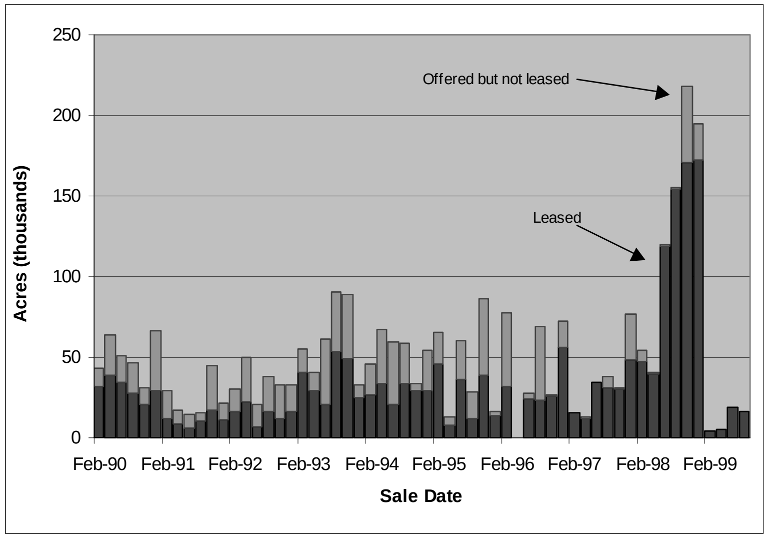
Figure 5 displays the drilling history in the BFOA for 1990-1998. There was a general decline in the number of wells drilled through 1994, with most wells drilling in the Minnelusa play. After 1994, total wells increase due to CBM drilling. Most wells listed as "others" on Figure 5 were drilled in the Shannon or Sussex sandstones.

Niobrara Formation Fractured Shale Play Economic development of the Niobrara Formation fractured shale play will almost certainly depend upon successful application of horizontal well technology. This play is currently in it's infancy and is somewhat problematic. Undiscovered reserves cannot be predicted with reasonable certainty, except that the potential recovery may be as large as several million barrels of oil and associated natural gas. Although horizontal wells were used to develop oil and gas reserves in fractured shale reservoirs in southeast Wyoming, overall results have been disappointing in the Powder River Basin. Unless there are a few economic wells drilled, it is unlikely that this play will have significant development in the foreseeable future.

LEASING

After initial field work, research, and subsurface mapping (which sometimes includes use of seismic data), leasing is often the next step in oil and gas development. Leasing may be based on speculation, with the most risky leases usually purchased for the lowest prices.

Leases on lands where the U.S. owns the oil and gas rights are offered via oral auction at least quarterly. Their maximum size is 2,560 acres and the minimum bid is $2.00 per acre. An administrative fee of $75.00 per parcel is charged and each successful bidder must meet citizenship and legal requirements. Leases are issued for a ten year term and a 12.5% royalty rate on production is required to be paid. Leases which become productive, are held by production and do not terminate until all wells on the lease have ceased production. Many private oil and gas leases contain a "Pugh clause", which allows only the developed portion of the lease to be held by production. However, federal leases have no such clause, allowing one well to hold an entire lease.



<u>Figure 6</u> Federal oil and gas lease acres offered and leased for BFOA. Data are from BLM files.

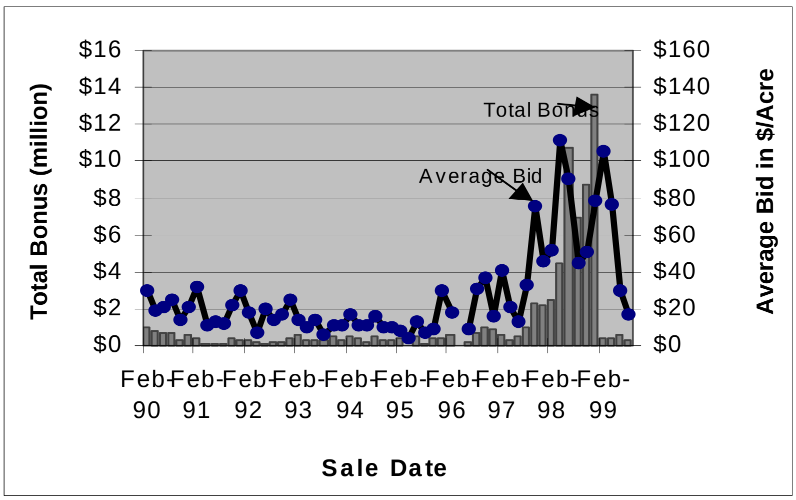
Wyoming lease sales are held on even numbered months, usually in Cheyenne. Since August 1996, only lands requested for lease have been offered. Before that, virtually all federal lands available for lease were offered at each sale. Each lease contains restrictive stipulations which protect potentially affected resource values.

The number of federal acres in the BFOA offered for lease and leased, on a sale-by-sale basis, is shown in Figure 6. No sale was held in April of 1996. Note the abrupt increase in acreage leased during the June-December 1998 period. For 1998, over 660,000 acres were leased. The additional acreage offered and leased, was mostly in Johnson and Sheridan counties. That increase was due to increased interest in CBM.

The total bonus bid amount for each sale and the average per acre bid for federal oil and gas leases in the BFOA are shown in Figure 7. Bids are shown on a sale-by-sale basis. Again, no sale was held in April of 1996. Note the steady decline in average bid before December 1995. Beginning in December 1995, the average bid began to increase. Bids began to increase at an even higher rate starting in August of 1997. Those increases were due almost entirely to increased interest in CBM. Since December 1998 the amount of acreage leased and bonus money received has dropped substantially. This is probably because nearly all available federal acreage in the CBM play area is now under lease.

For the period surveyed in Figure 7, about $83 million in total bid bonuses was received for land in the BFOA. About $51 million appears to have been bid to obtain leases for their CBM potential. Maps 3 and 4 highlight average dollar-per-acre bids compiled on a township-by-township basis. They compare federal oil and gas leasing in 1995 and 1998. These maps show the dramatic increase in lease biding in the CBM play area. Highest bids were centered in the BFOA.

Many of the federal leases in the CBM play area are large (more than 1,000 acres) and the entire lease will be held by production until the last well ceases production. For most leases this will be many years beyond their primary term. Since these leases will be held by production, it will be more difficult for others to acquire enough acreage to justify tests of deeper horizons. This will suppress development potential of the deeper horizons in the CBM play area.



<u>Figure 7</u> Federal oil and gas lease sale bid results for BFOA. Data are from BLM files.

The amount of federal oil and gas acreage under lease to 2010 is projected to be between 1.5 and 3.0 million acres. Acreage leased annually is projected to average between 100,00 and 500,000 acres. Average bids are estimated to be between $10 and $50 per acre.

SEISMIC SURVEYS

APPENDIX C

Seismic surveys on Bureau managed surface are authorized by approval of Notices of Intent to Conduct Geophysical Operations (Notices). From 1984 through 1998 the number of approved Notices has decreased substantially (Figure 8). Until a sustained oil price in excess of $30.00 per barrel occurs, the number of Notices will probably remain low. It is questionable whether a price increase would spur new Notices, since the BFOA already has extensive seismic coverage. Much of this existing data could probably be reprocessed with computers, rather than making new on-the-ground seismic surveys.

There has been recent interest in three-dimensional surveys. Although more expensive than conventional seismic surveys, they give a three-dimensional picture of the subsurface. Most of these surveys have been over or near oil fields in eastern Campbell County where there is little Bureau managed surface. If successful, three-dimensional surveys could increase Notices to about 15 per year. Seismic data is not generally used in the CBM play, therefore, activity in this play is not expected to increase the number of Notices.

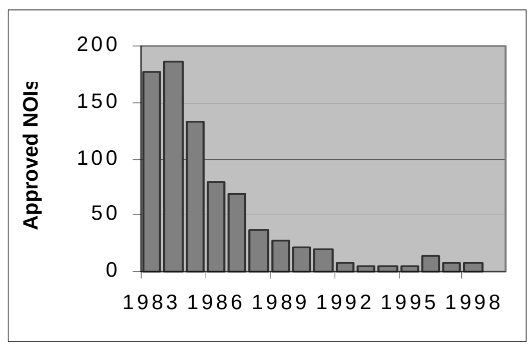
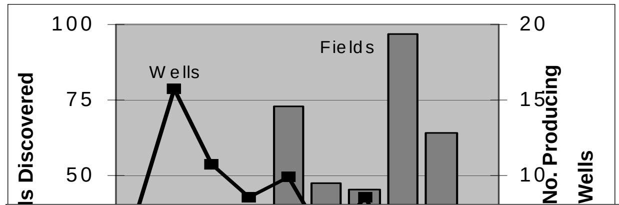


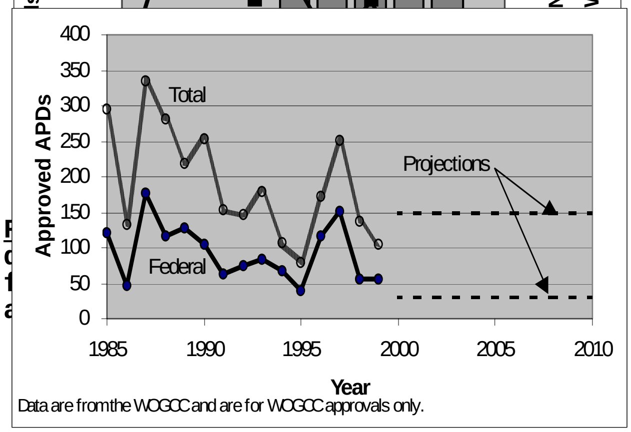
Figure 8 Approved Notices on BLM managed surface in the BFOA. Data are from BLM files.

DRILLING OPERATIONS

Non CBM Drilling

Before an oil or gas well is drilled, an Application for Permit to Drill (Permit) must be filed with the WOGCC. If the well will be on federal lands, the Permit must also be filed with the Bureau. Figure 9 plots the total and federal non CBM Permits approved for 1985-1999. The WOGCC approved 2,851 total Permits during that period. About 50% (1,397 Permits) were Federal. Around 80% were actually drilled.





<u>Figure 9</u> Approved non CBM Permits (APDs) and projections through 2010.

Historical data indicate there is a general correlation between the number of approved non CBM Permits and oil price. Although not shown here, this correlation indicates a sharp increase in Permits would not be expected until oil prices are above $25 to $30 per barrel for a sustained period.

Historical data indicates total non CBM Permits will range from 100 to 300 per year, through 2010. They could possibly go as high as 400 per year, although this is not likely unless oil prices are above $25-$30 per barrel for a sustained period. The number of approved Federal Permits is expected to range from 30 to 150 annually with a possible high of 200.

General areas of anticipated development activity in the BFOA are shown on Map 5. This map shows the general areas of anticipated drilling activity, exclusive of CBM, through 2010. It was drawn after reviewing information on:

$ areas of past drilling activity;
$ the oil and gas plays outlined by Dolton, et al (1990);
$ information obtained from Glaser (1992);
$ federal oil and gas lease sale results; and
$ a general knowledge of Powder River Basin geology.

New oil and gas fields will continue to be discovered. Their number and size are difficult to predict with confidence. As Figure 10 shows, the discovery rate of fields has been somewhat erratic, but the trend was upward until the 1981-1985 interval. Field discoveries peaked in the mid-eighties and the rate is now trending downward. During 1981-1990, an average of 16 non CBM fields were discovered annually in the BFOA. It is unlikely this field discovery rate will occur again. Past patterns indicate the number of new non CBM field discoveries should average between five and ten annually through 2010. Most of the total new fields discovered during the next several years will be CBM fields.

The size of field discoveries, as measured by the number of wells producing in 1997, shows a distinct downward trend over time (Figure 10). Many of the fields discovered since the mid-eighties are productive from the Minnelusa Formation. Although these fields typically produce from fewer than ten wells, they usually have relatively high oil recoveries on a per-well basis. About 20% of the non CBM fields discovered since 1980, produce less than 30,000 barrels of oil from only one well and are probably uneconomic.

Past trends suggests that newly discovered non CBM fields will produce from less than ten wells. Average field size of new discoveries will probably be from two to five productive wells per field.

Carbon Dioxide Drilling The injection of carbon dioxide gas into oil reservoirs to enhance recovery has received some attention by industry since the early 1980's. This type of enhanced oil recovery has been of great interest were existing waterflood operations in old fields are approaching the end of their productive lives. The Powder River Basin contains a large number of these types of oil fields that are candidates for carbon dioxide injection. A few pilot carbon dioxide floods have tested the feasibility of this process in the Powder River Basin. The oil and gas industry has been interested in proceeding with additional tests of this type of flooding, if a supply of carbon dioxide gas could be easily accessed. To get the volumes of gas required to operate a flood, a pipeline would be required to bring it to the local fields.

The Bureau is presently analyzing the affects of laying a pipeline(Petro Source Carbon Dioxide Pipeline Project Environmental Assessment) into the Powder River Basin from Baroil in south central Wyoming. The present target date for completion of this pipeline is late 2001 or prior to February of 2002. During this initial construction phase, the pipeline would only extend to the area of the Salt Creek and Sussex fields north of Casper. Howell Corporation appears to be the only company pursuing an early test of a carbon dioxide flood. They are actively planning a pilot flood in the north part of the Salt Creek Field for soon after the pipeline is installed. Westport Oil & Gas operates the Sussex field and does not appear to have immediate plans to start a flood. A second phase of pipeline construction is planned to the Hartzog

Draw area, to the northeast of the Salt Creek Field. That extension would not be completed until 2003.

Information received indicates that very few new carbon dioxide flood related wells are likely to result in the short term (to 2010), because of this new access to a cheaper source of carbon dioxide gas. Targets for these types of floods are the larger developed oil fields. These candidate fields will have been fully delineated by past drilling and already undergone some type of water flood. At present there is no conclusive engineering database to allow a determination of what the best flood candidates are. In addition to the Salt Creek and Sussex fields, a number of other fields have already had some type of pilot carbon dioxide flood or have been mentioned as having potential for a flood. Those potential candidate fields are; Hartzog Draw, House Creek, Rozet, Kitty, Slattery, Meadow Creek, Culp Draw, Triangle U, House Creek, Hilight, Mush Creek, Lance Creek, Mule Creek, Dillinger Ranch, Cole Creek, and Glenrock.

Existing wellbores are expected to be adequate for use in any carbon dioxide flood and few new wells will be needed. Some new wells may be required to optimize the pattern of injection or production from a reservoir. Most new wells would be placed on an existing pad, where that new wellbore would be needed to replace an existing wellbore that has to be abandoned due to technical problems. The number of potential new wells are included in the projection made above for total non CBM drilling.

Horizontal Wells Horizontal drilling results in the BFOA have been disappointing. If future attempts to exploit oil and gas reserves in the Niobrara or other formations are successful, horizontal drilling activity could rise abruptly. Because of this uncertainty, estimates of horizontal wells drilled per-year range from two to ten or higher.

CBM Drilling

Wyoming CBM development activities are currently "booming" in the BFOA. This "boom" will almost certainly continue for a few more years, with the eastern side of the CBM development area (Map 2) being developed first. Because the western part of the CBM area contains a larger amount of federal mineral acreage than the eastern part of the CBM play area, delays in approving federal Permits may slow development in the western part of the area.

APPENDIX C

An estimate of recoverable resources was first required, to be able to determine reasonably foreseeable development scenarios for CBM drilling. See the "Oil and Gas Production" section (below) for procedures used to determine recoverable CBM resources for the five counties in Wyoming and for the Montana portion of the Powder River Basin. Using the estimate of recoverable resources, three scenarios for reasonably foreseeable development of CBM are predicted. The high resource estimate (28 trillion cubic feet of gas (TCFG)) was used in order to determine the maximum number of wells that can reasonably be expected to develop this play. The graphs shown below (Figures 11 and 12) are based on calculated reserves of 28 TCFG.

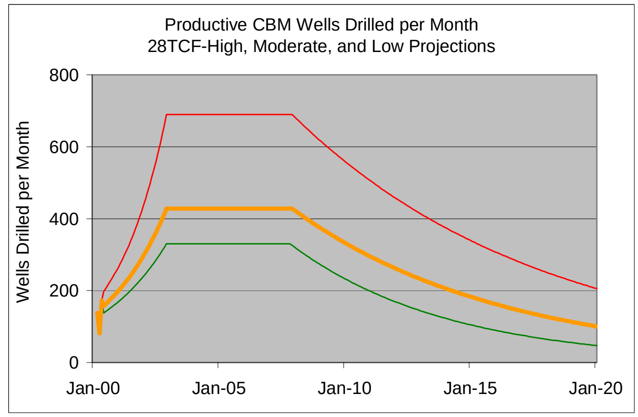


Figure 12 Estimate of productive wells drilled per month for low, high, and moderate scenarios.

The three scenarios described are based on average recoveries of 0.20, 0.35, and 0.50 BCFG per well. These three average well recoveries allow low, moderate, and high projections of the cumulative number of wells that could be drilled (Figure 11). The moderate scenario projects 81,000 total CBM wells in Wyoming, with 50,000 wells drilled by 2010. The high scenario projects 139,000 total wells, with 80,000 being drilled by 2010.

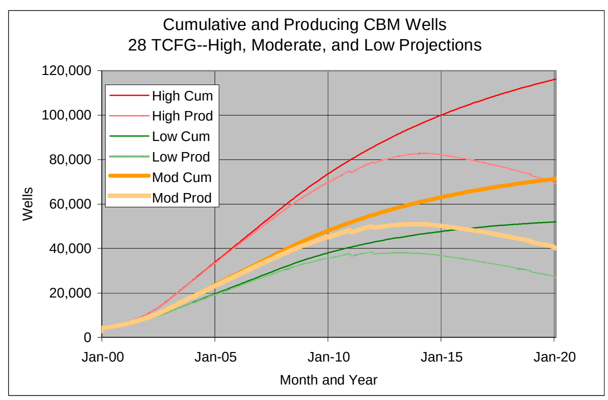


Figure 11 Projections of cumulative wells drilled and total producing wells for low, moderate, and high CBM scenarios. Data used are from WOGCC and BLM.

Curves showing the number of wells producing at one time are also shown on Figure 11. They are derived from the cumulative drilling projection curves. The low projection indicates the maximum number of wells producing at one time is 38,000. The high projection is 81,000 producing wells. Notice that for all three scenarios the number of producing wells increases until 2013-2014 then declines 10-16 percent per year.

The number of wells drilled monthly is also projected for three scenarios (see Figure 12). These projections were derived from the graph shown in Figure 11. They are based on historical trends, drilling time, well depth, and estimated Permit approval rates. The minimum drilling rate is estimated to be 330 wells per month (3,960 wells per year) for the height of drilling activity (January, 2003 through December, 2007). A maximum rate was projected to be 690 wells per month (3,960 wells per year). About one-half of these wells would be federal.

Montana Recent proposals by operators indicate 9,551 wells will be drilled in the Montana portion of the Powder River Basin by 2010. This well projection appears to be too high, as discussed below in the "Recoverable CBM Resources in Montana" section.

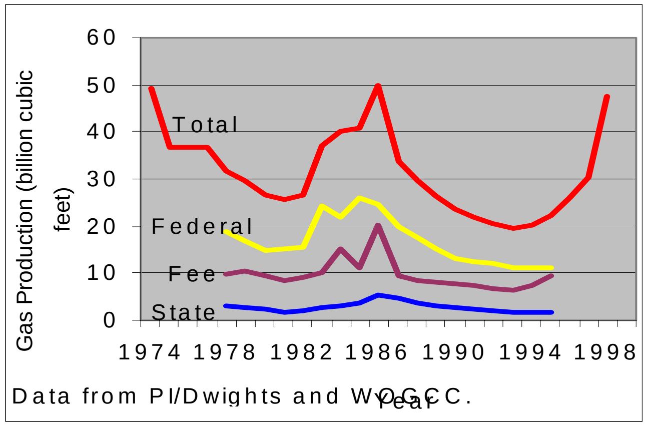


Figure 14 Gas production from federal, fee, and state wells in the BFOA.

OIL AND GAS PRODUCTION

Non CBM Production

Oil production from wells on federal, fee, and state minerals is shown in Figure 13. Production during 1984-1991 was relatively stable, but has declined sharply since. The decline averaged eight percent per year from 1991-1998. During 1990-1995 oil production from wells on federal minerals averaged 51% of the total oil production.

Oil production will continue to decline about five to eight percent per year, unless large new discoveries are made, or there is a long term increase in price. A price increase would stimulate the search for new deposits, allow old fields to be produced longer, and allow increased use of enhanced oil recovery methods. It is unlikely that annual oil production will again reach 30 million barrels.

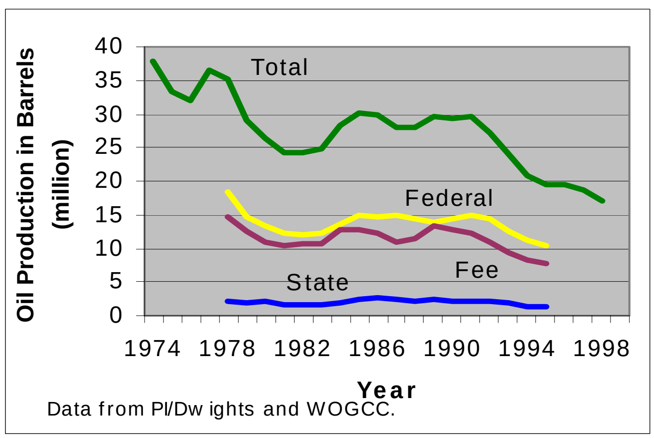


Figure 13 Oil production from federal, fee, and state wells in the BFOA.

Gas production from wells on federal, fee, and state minerals has been much more erratic (Figure

14). Total gas production declined 53 percent from 1987-1994. In 1994, CBM was only 12 percent of total gas production in the BFOA. The gas production decline was reversed in 1995 due to increasing CBM production. Total gas production increased 21 percent per year since 1994. This trend is expected to continue.

The total number of non CBM producing wells in the BFOA increased from 1978-1984, but has decreased since 1990. The number of wells will probably continue to decrease through 2010, although there may be a few year-to-year increases. During 1990-1994, 58 more non-CBM federal wells were abandoned per year than were drilled per year. This trend is expected to continue, but the number of wells plugged in excess of the number of new wells drilled will probably decrease.

During 1990-1995, about 50 percent of the total producing wells in the BFOA were federal wells. The number of productive federal wells is expected to remain at about 50% of total productive wells.

CBM Production

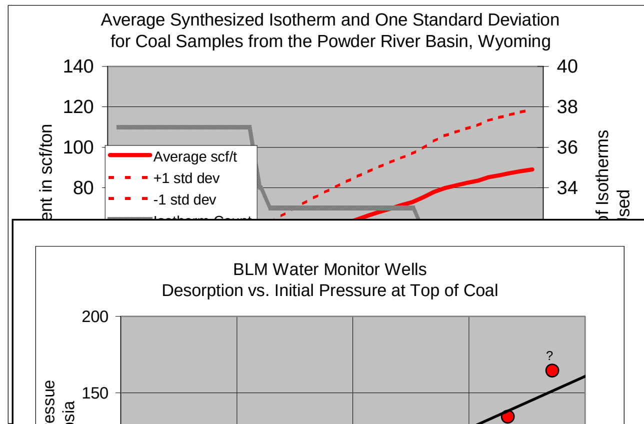
Summary Recoverable resource estimates for CBM in the Powder River Basin vary widely. Five sets of recent estimates (including our estimates) are listed in Table 2. Because of the variation, the Wyoming Reservoir Management Group took the latest available information and made additional calculations for gas-in-place and recoverable CBM resources. Recently available coal tonnage, gas content, and water pressure data were used in these calculations. The data, some of which is still proprietary, allowed detailed calculations of total gas-in-place in the Powder River Basin. A range of recovery factors was used, therefore there is a range of estimated recoverable CBM resources.

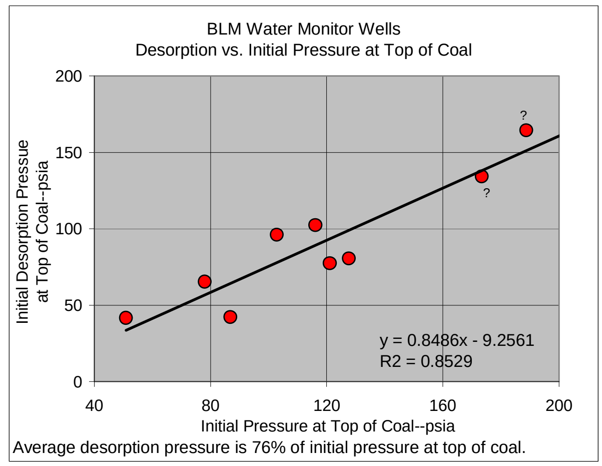
Ninety eight percent of the CBM resources are in Campbell, Johnson, and Sheridan counties, Wyoming. Converse and Natrona counties contain the remaining two percent. Montana contains about two percent of the total estimated CBM methane resources in the Powder River Basin, excluding native lands.

Recoverable Res. TCFG	Source	Date
4.198-8.396-14.273	Potential Gas Comm.	March, 1998
9.329	Gas Research Inst.	1999
25.2	Goolsby and Assoc.	August, 1999
14.6	Lance Oil and Gas	August, 1999
16-23-28	BLM-WRMG	November, 2000

Table 2 Recent estimates of recoverable coal gas for the Powder River Basin. The Lance Oil and Gas estimate is unpublished.

Future CBM drilling was estimated (see "CBM Drilling", above) using 28 TCFG as the recoverable gas reserve. This is the high estimate and was used to assess possible impacts at the highest potential drilling





<u>Figure 17</u> Correlation between pressure at the top of the coal and initial coal gas desorption pressure in water monitor wells.

depths. The pressure at the top of the coal must first be determined. To get an estimate of that pressure, data from 18 water monitor wells was used to correlate depth of the coal and depth to the top of water (piezometric surface). Figure 16 shows this correlation. Several of these wells are clustered in one area, therefore those wells were averaged and one averaged well was plotted on the graph. If the depth to top of coal is known, then Figure 16 is used to determine depth to top of water. The depth to top of water is then multiplied by 0.433 psi/foot (fresh water gradient) to obtain pressure at the top of the coal of interest.

4. The water monitor well data indicates that the pressure exerted by the water in the coal does not allow its gas to escape. Therefore, some water must first be removed to lower pressure, and allow the coalbed methane to desorb. At some point pressure will be lowered enough for the gas in the coal to be desorbed. The initial desorption pressure can be estimated by using water monitor well data. Several water monitor wells have measured the lowering of the water level and initial gas desorption pressure. Figure 17 shows a correlation between initial pressure at the top of the coal and initial desorption pressure. After initial desorption pressure is determined the graph in Figure 15 can be used to estimate gas content in the coal. Coal gas contents in standard cubic feet per ton (scf/ton)used for specific depth intervals are shown in Table 3.

5. Gas-in-place calculations can be made by multiplying coal tonnage for specified depth intervals (calculated in item 1, above) by the coal gas contents listed in Table 3. Results of calculations for gas-in-place, by county, are shown in Table 4. Calculations were made only for coals in the Fort Union and Wasatch formations. Coals in Cretaceous and older formations were not included. They probably do not contain any significant CBM resources when compared with coals in the shallower Fort Union and Watch formations.

Depth	Recovery Factors		
	Low	Moderate	High
0-200 ft.	2%	10%	25%
Over 200 ft.	50%	65%	80%

<u>Table 5</u> Recovery factors used to calculate CBM resources in the Powder River Basin.

6. After gas-in-place has been calculated, recovery factors can be applied to determine recoverable gas resources. Recovery factors used in this estimate of recoverable resources are summarized in Table 5. Determination of a recovery factor is difficult and subject to considerable speculation, therefore a range of recovery factors (low, moderate, and high) was used.

<u>Recoverable CBM Resources in Wyoming</u> Using the procedure described above, recoverable resources for five counties in Wyoming were calculated. Table 4 shows the low, moderate, and high estimates for recoverable resources for each county. The high estimate totals 28 TCFG for the Wyoming part of the Powder River Basin.

<u>Recoverable CBM Resources in Montana</u> The resource in the Montana part of the Powder River Basin is minor relative to Wyoming's resource. Using the approach described above in "Methodology", gas-in-place resources are 479 BCFG and recoverable resources are 205 to 343 BCFG. Only about one and a half percent the total Powder River Basin gas-in-place is in Montana, exclusive of the Indian reservations.

County	Gas-In-Place BCFG	Recoverable Resources (BCFG)		
		Low	Moderate	High
Campbell	15,411	7,644	9,945	12,258
Converse	666	327	426	526
Johnson	13,523	6,722	8,741	10,773
Natrona	24	12	15	19
Sheridan	5,933	2,928	3,810	4,703
WY Total	35,557	17,633	22,937	28,279

<u>Table 4</u> Gas-in-place and estimates of recoverable CBM resources for the Powder River Basin.

Recent operator proposals indicate 9,551 wells will be drilled in Montana by 2010. The average well is projected to recover 0.3 BCFG. Multiplying total wells by recovery per well, indicates at least 2,900 BCFG would be recovered. This is much larger than the 205 to 343 BCFG thought to be recoverable from the coals. The number of actual CBM wells that could be drilled to produce the recoverable resource of 205 to 343 would be much less than the 9,551 wells proposed.

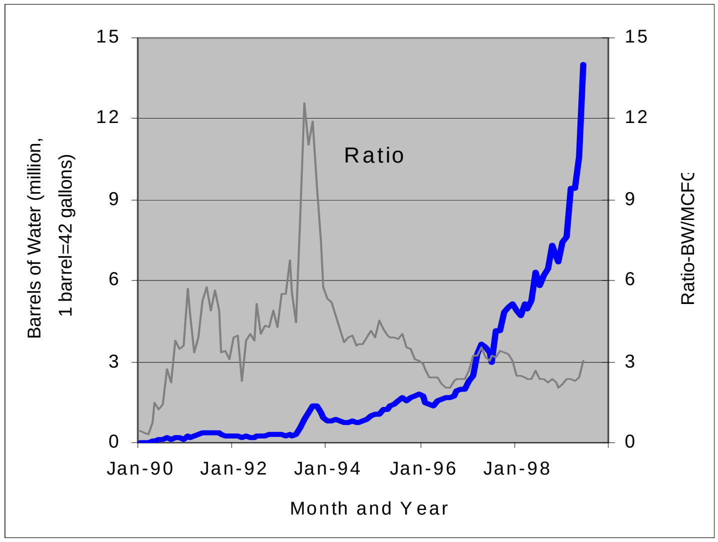


Figure 17 Water production associated with CBM production in the BFOA. One million barrels of water is equivalent to 129 acre feet. Data from WOGCC.

Water Production Large quantities of water are produced with CBM. During June 1999, 3.4 barrels of water were produced for every thousand cubic feet of CBM. This ratio should decrease over time because water production generally declines during the life of a CBM well. Figure 18 shows water production associated with CBM production in the BFOA. During June 1999, 14 million barrels of water (1,800 acre feet) were produced in the BFOA.

CONCLUSIONS

A "boom" in CBM development is currently underway in the BFOA. Gas production has increased sharply and will probably continue to increase for the next few years. Oil and gas development, exclusive of CBM, will continue to slowly decline. Oil production will continue to decline. Seismic activity as measured by the number of approved Notices, has increased from the low activity levels of the early 1990s but will probably not go much higher. The amount of federal acreage under lease has increased substantially since 1997. Because federal leases do not contain a "Pugh clause", much of the federal acreage under lease in the CBM area will be held by production for many years after the primary lease term.

APPENDIX C

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APPENDIX C

GLOSSARY

Abandon To cease producing oil and/or gas from a well. This may involve several steps: one or more cement plugs are placed in the borehole to prevent migration of fluids between the different formations, equipment is removed, and the wellsite is reclaimed.

Acquired Minerals Mineral rights that were patented into non federal ownership and were later reacquired by the United States.

BCFG Billion cubic feet of gas.

BOPD Barrels of oil per day, this is usually the unit of measure for oil production at the wellhead. One barrel is 42 U.S. gallons.

BFOA Buffalo Field Office area, comprised of Campbell, Johnson, and Sheridan counties, Wyoming.

CBM Coalbed methane, natural gas originating from and residing in coal beds.

Development Potential Oil and gas development potentials are based on estimated average drilling density and are defined as follows: HIGH--over one well/township/year, MODERATEB-0.2 to 1.0 wells/township/year, LOW--less than 0.2 wells/township/year, VERY LOW-- less than 0.02 wells/town ship/year, ZERO--no drilling.

Enhanced Oil Recovery A process where chemicals such as surfactants or carbon dioxide are injected into the reservoir to mix with the oil so that additional oil can be recovered.

MMBO Million barrels of oil.

Occurrence Potential HIGH--There is a demonstrated existence of petroleum source, reservoir quality strata, and traps. Areas of high potential have discovered oil occurrences or free oil recovery from well tests. MODERATE--There is direct or indirect geological evidence that petroleum source, reservoir quality strata, and trapping mechanisms are present. Discovered occurrences are not present but there may be shows of oil in core or drill stem tests. LOW--There is geological evidence that a petroleum source, reservoir quality strata, or trapping mechanisms are not present. NONE--There is a demonstrated absence of a petroleum source, reservoir quality strata, or trapping mechanisms. Demonstrated absence means physical evidence documented in geological literature.

Oil and Gas Field A natural accumulation of oil and gas in the subsurface. Oil and gas may be present in two or more reservoirs at different depths.

Oil and Gas Lease A federal oil and gas lease is a legal document that gives the lease holder the right to explore for and develop any oil and gas that may be present under the area designated in the lease while complying with any surface use conditions which may have been stipulated when the lease was issued.

Oil and Gas Reservoir A geologic layer containing hydrocarbons and enough porosity and permeability so that the hydrocarbons can be produced.

Play The geographic extent of an oil and/or gas bearing formation or interval.

Public Domain Minerals Mineral rights that have always been the property of the United States.

Pugh Clause A term in an oil and gas lease that prevents a productive well from holding acreage not allocated to that well. In other words if well spacing is 40 acres/well, one well cannot keep more than 40 acres of the oil and gas lease from expiring after the primary term of the lease.

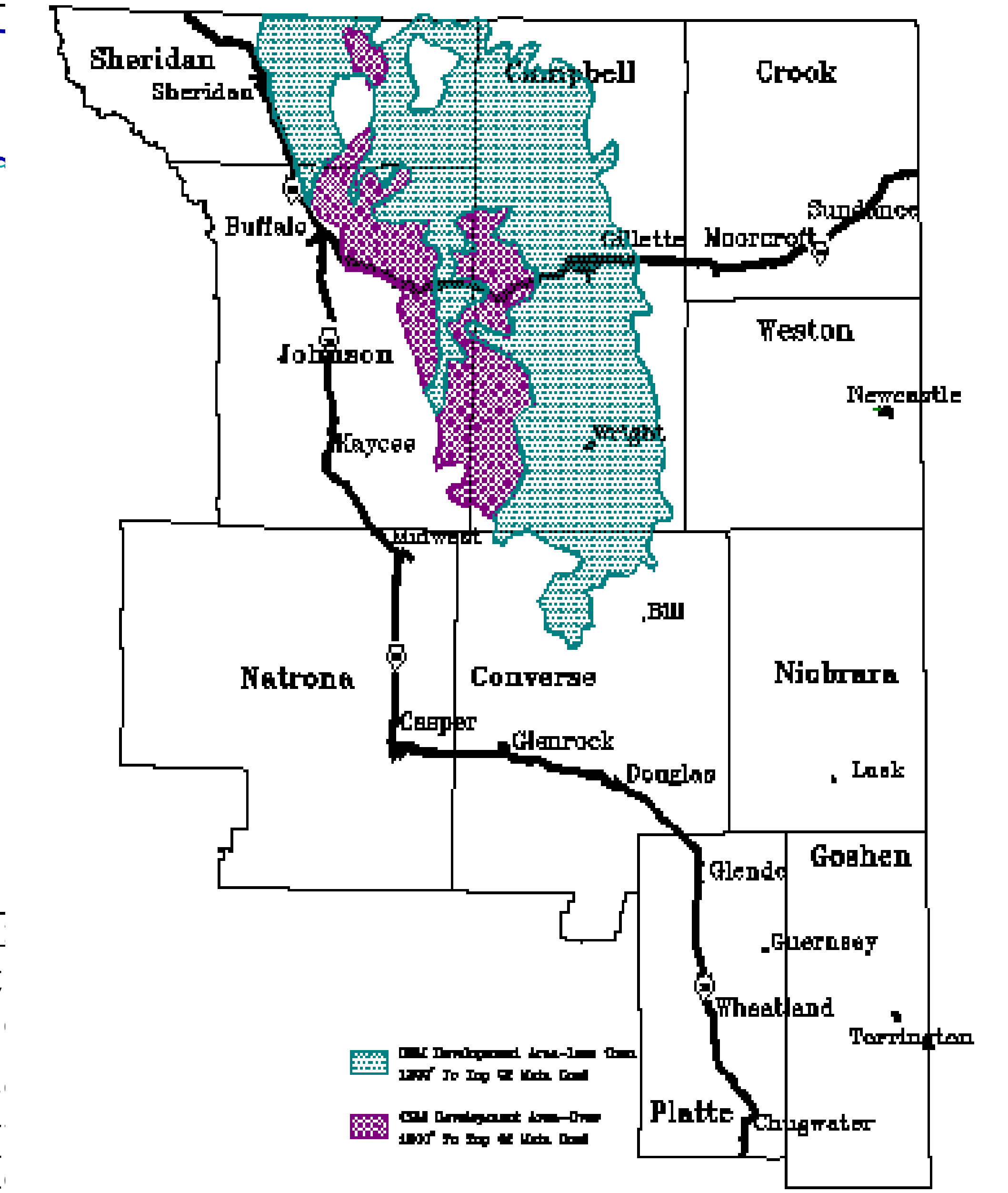
Secondary Recovery A process whereby pressure in an oil and gas reservoir is artificially maintained or increased so that more oil can be recovered. This is usually done by injecting water or natural gas into the reservoir.

WOGCC Wyoming Oil and Gas Conservation Commission

APPENDIX C

Table 1 Summary of all the oil and gas plays evaluated by Dolton, et al (1990). The reader is cautioned against estimating undiscovered reserves in the BFOA based on this table.

Oil and Gas Play	Total Play area	Play Area in BFOA	% of Play Area in BFOA	% of BFOA in Play Area	No. of fields	Estimated Reserves		Remarks
						MMBO	BCFG	
Basin Margin Anticline	8.12	1.37	16.9%	18.6%	5	24	21	Exploration nearing conclusion, future discoveries probably in small subtle traps.
Basin Margin Subthrust	2.12	0.54	25.5%	7.3%	NA	NA	NA	Geologic data limited, accurate prediction of future reserves or field sizes not possible.
Dakota	18.63	0.77	4.1%	10.5%	21	158	158	
Deep Frontier	5.47	0.85	15.6%	11.6%	6	37	100	
Lakota	21.21	4.06	19.2%	55.2%	NA	NA	NA	Undiscovered fields are probably small.
Leo	8.05	0.30	3.7%	4.0%	60	110	30	
Mesaverde & Lewis (stratigraphic)	7.99	3.41	42.7%	46.3%	10	66	91	
Minnelusa (total)	17.01	3.22	18.9%	43.7%	165	822	203	In explored area most discoveries will be fields with 3MMBO or less. In unexplored area field size will be similar to explored area.
Minnelusa (explored area)	NA	NA	NA	NA	26	48	10	
Minnelusa (unexplored area)	NA	NA	NA	NA	139	775	194	
Minnelusa (less prospective)	4.93	0.00	0.0%	0.0%	NA	NA	NA	
Mowry Shale	11.63	3.96	34.1%	53.9%	NA	NA	NA	Lightly explored, possible large nonconventional resource.
Muddy (total)	21.25	4.04	19.0%	55.0%	39	441	1298	
Muddy (explored area, shallow)	NA	NA	NA	NA	10	60	82	
Muddy (unexplored area, deep)	NA	NA	NA	NA	30	381	1216	
Shannon marine shelf	8.40	4.07	48.4%	55.3%	20	128	103	Sx & Sh combined
Sussex marine shelf	10.77	3.46	32.1%	47.0%	(combined w/shannon)			



Map
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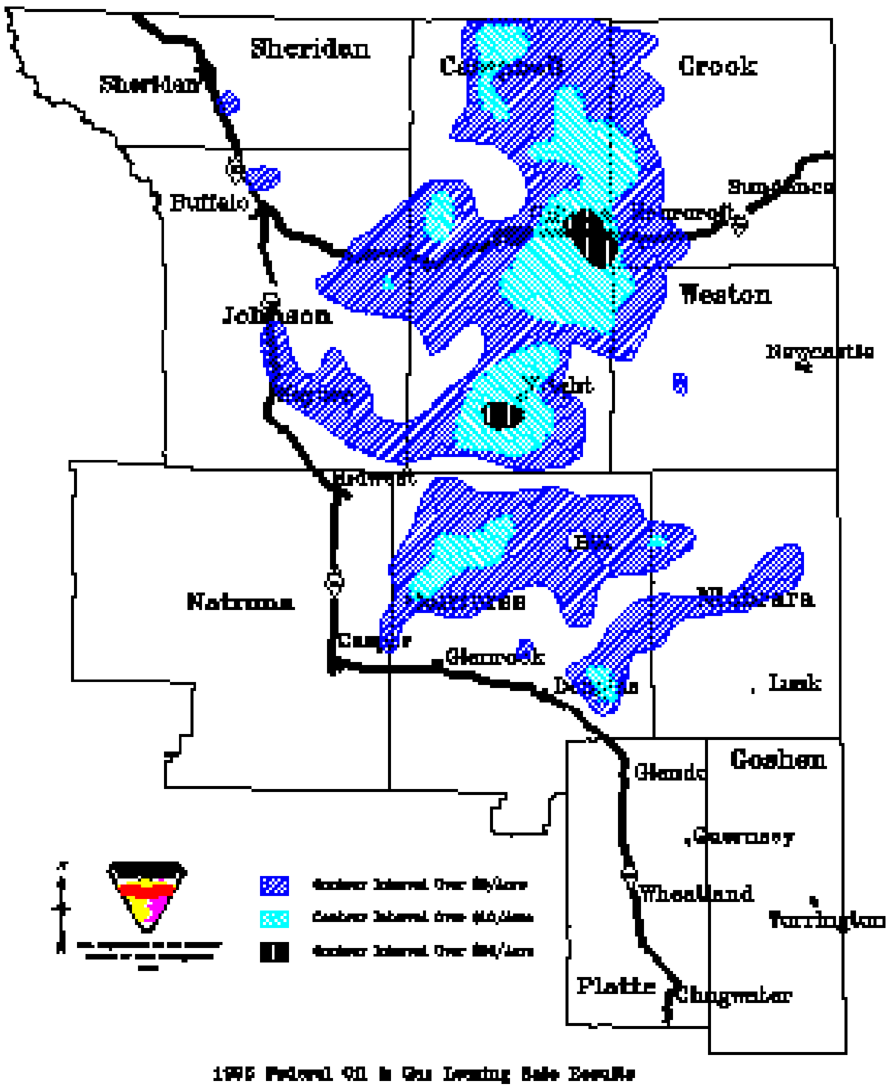
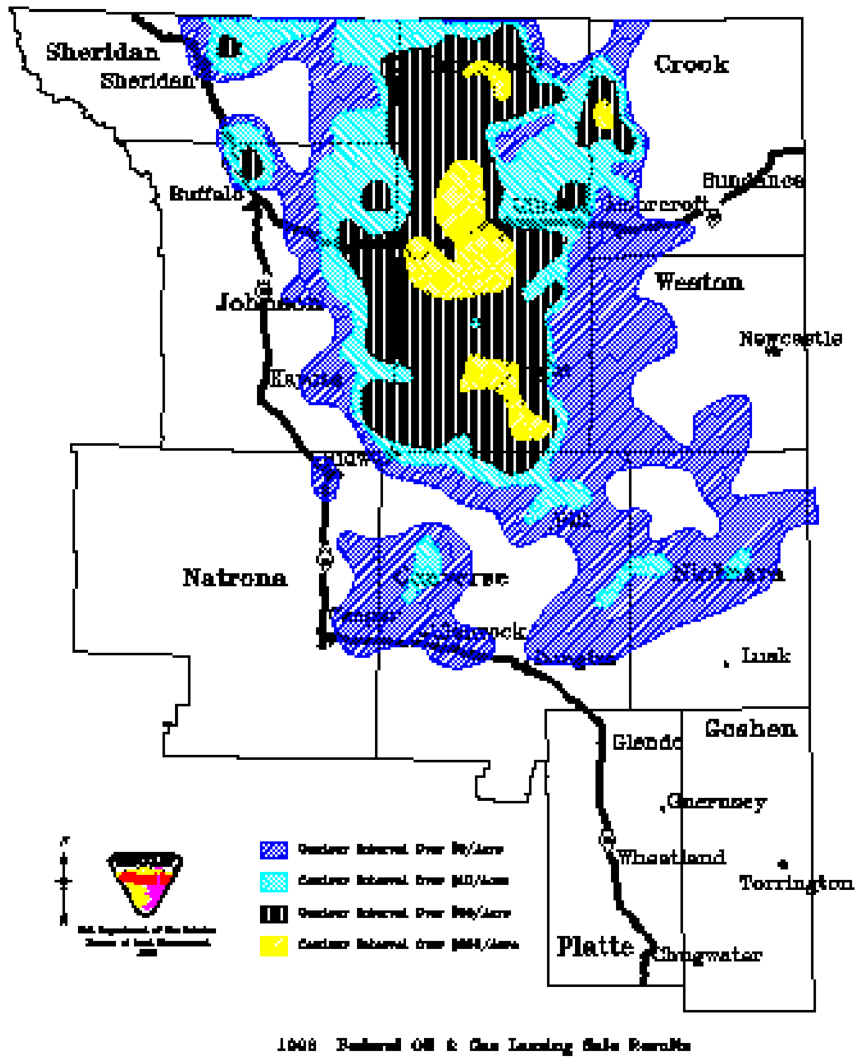
There is a demonstrated absence of source rock, thermal maturation, and reservoir rock that precludes the occurrence of hydrocarbons. Demonstrated absence means physical evidence documented in geological literature.

Map 2 CBM development area. The boundary is based on depth to top of coal, thickness of thickest coal, drilling activity, and federal oil and gas lease sale results.

APPENDIX C

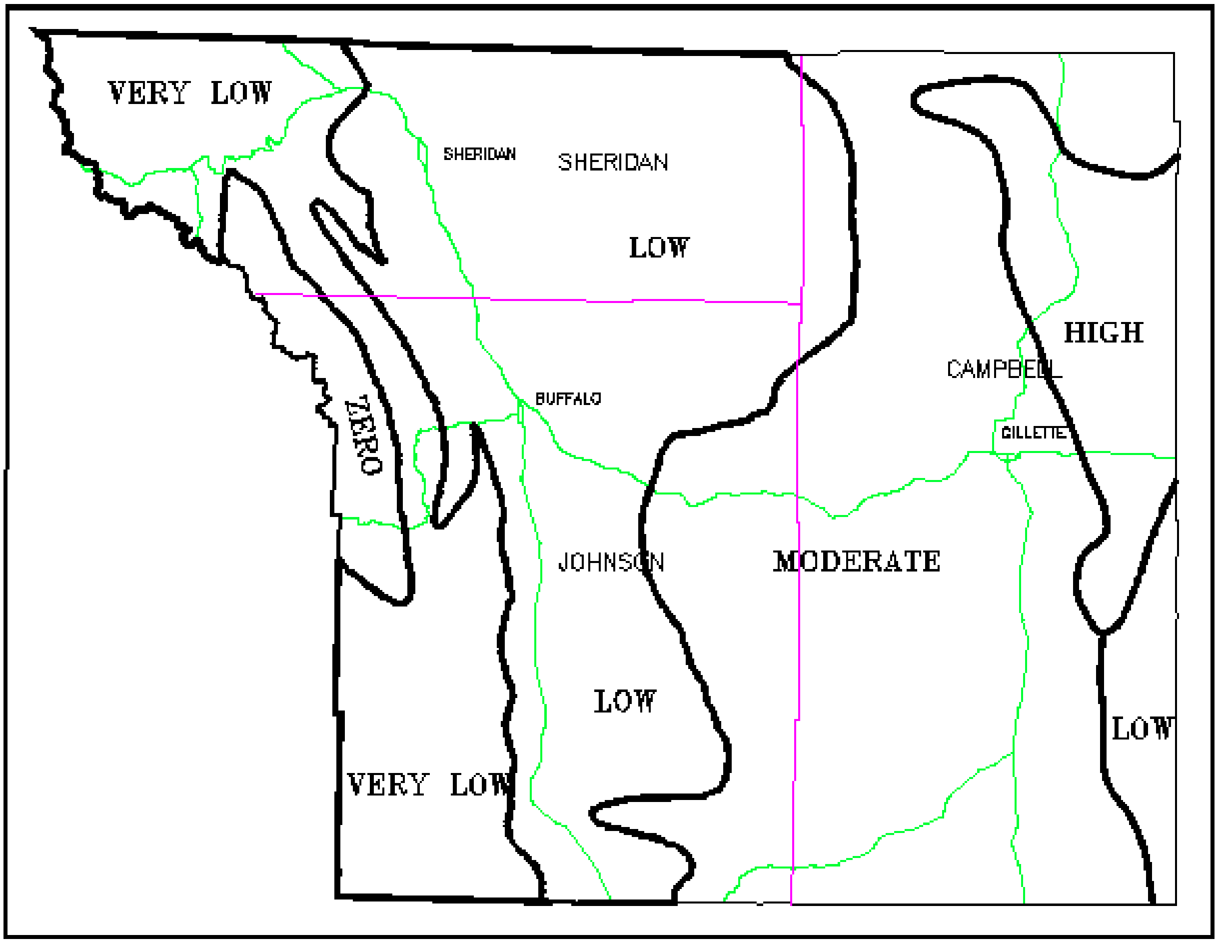


Map 3 Average dollar-per-acre bids from 1995 federal oil and gas lease sales. Intervals were mapped at bid prices of $2.00, $10.00, and $50.00 per acre. Data were compiled on a township-by-township basis.



Map 4 Average dollar-per-acre bids from 1998 federal oil and gas lease sales. Intervals were mapped at bid prices of $2.00, $10.00, $50.00, and $200.00 per acre. Data were compiled on a township-by-township basis.

APPENDIX C



Map 5 Oil and gas development potential map for non CBM wells in the BFOA. Development potential is based on estimated drilling density and is defined as follows: HIGHB greater than 1 well/township/year; MODERATEB 0.1 to 1.0 well/township/year; LOWB 0.02 to 0.09 well/township/year; VERY LOWB less than 0.02 well/township/year; ZEROB no drilling expected.